Claims

[c1] 1.A method for processing medical images for use in the detection and diagnosis of disease comprising:
classifying regions of interest within the medical images based on a hierarchy of anatomical models representative of anatomical information indicative of a given disease and signal models of signal information of an image acquisition device used to acquire the medical images.

[c2] 2.The method of claim 1 further comprising the step of presenting the regions of interest from the classifying step, wherein the presenting step comprises at least one of displaying the regions of interest, displaying a plurality of decision parameters and displaying anatomical context of the regions of interest.

[c3] 3.The method of claim 1 wherein the hierarchy of anatomical models comprise at least one geometric information, shape information, pixel intensity, size information and anatomical information derived from expert observation and knowledge of the given disease and further derived from expert description of characteristics of the given disease.

[c4] 4.The method of claim 1 wherein the signal models comprises at least one of a scanner point spread function or the impulse response of the image acquisition device and the X-ray density, brightness, resolution and contrast of anatomical structures.

[c5] 5.The method of claim 1 wherein the classifying step further comprises the step of comparing respective anatomical models using Bayes Factors to differentiate tissue types in the images.

[c6] 6.The method of claim 1 wherein the classifying step further comprises image segmentation processing.

[c7] 7.The method of claim 5 further comprises presenting results of tissues types differentiated in the comparing step.

[c8] 8.The method of claim 1 wherein the image acquisition device is selected from at least one of a computed tomography (CT) scanner, a magnetic resonance

imaging (MRI) scanner, ultrasound scanner, positron emission tomography scanner and a X-ray device.

[c9] 9.The method of claim 1 wherein the anatomical models correspond to a characteristics of diseased lung tissue.

[c10] 10.A method for identification of at least one suspect region of interest in acquired medical images of a subject, comprising:
grouping a plurality of mathematical models corresponding to anatomical and tissue characteristics into a hierarchy of anatomical models for tissue and region differentiation, the anatomical models being selected to be representative of anatomical information indicative of a given disease;
classifying regions of interest within the medical images based on the hierarchy of anatomical models and further based on signal models corresponding to a given image acquisition device used to acquire the medical images; and,
presenting the results of the competing step for use in identifying suspicious regions in the medical images.

[c11] 11.The method of claim 10 wherein the signal models comprises at least one of a scanner point spread function or the impulse response of the image acquisition device and the X-ray density, brightness, resolution and contrast of anatomical structures.

[c12] 12.The method of claim 10 wherein the classifying step further comprises the step of comparing respective anatomical models in pairs using Bayes Factors to differentiate tissue types in the images.

[c13] 13.The method of claim 10 wherein the classifying step is performed by a combination of Bayesian competition and neural networks.

[c14] 14.The method of claim 10 wherein the presenting step comprises at least one of displaying the regions of interest, displaying a plurality of decision parameters and displaying anatomical context of the suspicious regions in the medical images.

[c15] 15.The method of claim 10 further comprising;

interfacing with a user during the presenting step wherein the user inputs queries regarding the anatomical context of each suspicious region and the decision process.

[c16] 16.The method of claim 10 wherein the hierarchy of anatomical models comprise at least one geometric information, shape information, pixel intensity, size information and anatomical information derived from expert observation and knowledge of the given disease and further derived from expert description of characteristics of the given disease.

[c17] 17.The method of claim 16 wherein the hierarchy of anatomical models are derived for lung nodules, the vascular structure, and lung parenchyma.

[c18] 18.The method of claim 10 wherein the plurality of medical images are acquired by an image acquisition device and the image acquisition device is selected from at least one of a computed tomography (CT) scanner, a magnetic resonance imaging (MRI) scanner, a X-ray device, an ultrasound scanner, and a positron emission tomography (PET) scanner.

[c19] 19.The method of claim 10 wherein the medical images are of a lung.

[c20] 20.A method for identifying and quantifying tissue types from a plurality of acquired medical images for use in diagnosing lung disease comprising
segmenting the acquired image data to define the lung region;
computing low level features in the images using the known characteristics of the imaging device and the imaging process;
computing a hierarchy of anatomical models representative of anatomical features in the images;
grouping regions in the image into anatomical structures; and,
identifying areas within the grouped regions representing areas which are suspicious for at least one given lung disease.

[c21] 21.The method of claim 20 further comprising presenting the areas identified as suspicious for lung disease.

[c22] 22.The method of claim 21 wherein the presenting step comprises presenting

an anatomical context of an identified suspicious area and a decision process by which the suspicious area was identified.

[c23] 23.The method of claim 20 wherein the medical images are acquired from at least one of a computed tomography (CT) scanner, a magnetic resonance imaging (MRI) scanner, an ultrasound scanner, and a positron emission tomography scanner, or a X-ray device.

[c24] 24.The method of claim 20 wherein the grouping of regions into anatomical structures is performed by Bayesian competition in accordance with the hierarchy of anatomical models.

[c25] 25.A method for characterizing tissue in medical images for use in disease diagnosis and detection comprising:
computing an information object hierarchy of increasing complexity to characterize anatomical tissue, the object hierarchy containing models based on characteristics an image acquisition device and anatomical characteristics of at least one given disease;
comparing information using Bayes Factors at levels of the object hierarchy to identify suspicious tissue indicative of disease.

[c26] 26.The method of claim 25 wherein the anatomical characteristics are at least one of geometric shape and intensity values.

[c27] 27.The method of claim 25 wherein the object hierarchy further comprises a plurality of signal models based on characteristics of an image acquisition device used in acquiring the images and plurality of models based on anatomical characteristics of a selected region of interest and the at least one given disease.

[c28] 28.The method of claim 25 wherein the hierarchy comprises a low level corresponding to signal models representative of the image acquisition device and a high level corresponding to anatomical models derived in accordance with expert observation and knowledge of the at least one given disease.

[c29] 29.The method of claim 25 further comprising a plurality of intermediate levels

defining geometric models, shape models, intensity models derived from the anatomical models at the high level.

[c30] 30.The method of claim 25 where the at least one given disease is lung disease.

[c31] 31.The method of claim 28 wherein the anatomical models at the high level correspond to lung nodules indicative of lung disease, vascular structure and lung matrix tissue.

[c32] 32.The method of claim 31 further comprising a plurality of intermediate levels defining shape models and intensity models characteristic of lung nodules.

[c33] 33.The method of claim 31 further comprising a plurality of intermediate levels defining shape models and intensity models characteristic of lung vascular structure.

[c34] 34.The method of claim 31 wherein the Bayes Factor is a ratio of posterior model probabilities given intensity and shape data for two given models M=1 and M=2, and where x=intensity data, θ_1 =geometric model for M=1 and θ_2 =geometric model for M=2 and is expressed as:

$$\frac{p(M=1|x,\theta_1,\theta_2)}{p(M=2|x,\theta_1,\theta_2)}.$$

[c35] 35.A system for processing medical images acquired by an image acquisition device for use in the detection and diagnosis of disease comprising:
a processor coupled to the image acquisition device, the processor is adapted to identify suspicious regions within the medical images based on an information object hierarchy and a Bayes Factors competition framework using at least one of anatomical models and signal models; and,
an interface coupled to the processor adapted to present information relating to the suspicious regions identified by the processor, the information being used for diagnosis and detection.

[c36] 36.The system of claim 35 wherein the anatomical models comprise at least one of lung nodules and vascular structure indicative of lung disease.

[c37] 37.The system of claim 35 wherein the hierarchy comprises models of increasing complexity for use in identifying suspicious regions.

[c38] 38.The system of claim 35 wherein the interface is further adapted to receive user queries regarding an anatomical context of the suspicious regions and a decision process for identifying each of the suspicious regions.

[c39] 39.The system of claim 35 wherein the signal models comprises at least one of a scanner point spread function, the impulse response of the image acquisition device and the X-ray density, brightness, resolution and contrast of anatomical structures.

[c40] 40.The system of claim 35 wherein the image acquisition device is selected from at least one of a computed tomography (CT) scanner, a magnetic resonance imaging (MRI) scanner, an ultrasound scanner, and a positron emission tomography scanner, and a X-ray device.

[c41] 41.The system of claim 35 wherein the Bayes Factor competition uses the Bayes Factor, the Bayes Factor being to a ratio of posterior model probabilities given intensity and shape data for two given models M=1 and M=2, and where x=intensity data, θ_1 =geometric model for M=1 and θ_2 =geometric model for M=2 and is expressed as:

$$\frac{p(M=1|x,\theta_1,\theta_2)}{p(M=2|x,\theta_1,\theta_2)}.$$

[c42] 42.The system of claim 35 wherein the processor is further adapted to automatically segment the pleural space.

[c43] 43.The system of claim 35 wherein the processor is further adapted to group a plurality of anatomical and signal models into the hierarchy of models for use in the competition framework.

[c44] 44.The system of claim 35 wherein the medical images are acquired of at least one of a lung, a colon, a breast, a brain and a limb.

[c45] 45.A computer-aided system for use in the diagnosis and detection of disease

comprises:

an image acquisition device for acquiring a plurality of image data sets; and,

a processor adapted to process the image data sets and to classify selected tissue types within the image data sets based on a hierarchy of signal and anatomical models and the processor is further adapted to differentiate anatomical context of the classified tissue types for use in the diagnosis and detection of disease.

[c46] 46.The system of claim 45 further comprising an interface unit for presenting the classified tissue types within the image data sets and the anatomical context of the classified tissue types for aiding an interpretation of the processed image data sets.

[c47] 47.The system of claim 45 wherein the image acquisition device is at least one of a computed tomography (CT) X-ray system, a magnetic resonance imaging (MRI) system, an ultrasound scanner, and a positron emission tomography scanner, and a X-ray system.

[c48] 48.The system of claim 45 wherein the anatomical context comprises at least one of lung nodules and vascular structures indicative of lung cancer, healthy lung tissue, and diseased lung tissue indicative of chronic obstructive pulmonary disease (COPD).

[c49] 49.The system of claim 45 wherein the hierarchy comprises models of increasing complexity for use in identifying regions indicative of a given disease.

[c50] 50.The system of claim 46 wherein the interface unit is further adapted to receive user queries regarding anatomical context indicative of a suspicious region and a decision process for identifying the suspicious region.

[c51] 51.The system of claim 45 wherein the image data sets are acquired of at least one of a lung, a colon, a breast, a brain and a limb.

[c52] 52.The system of claim 45 wherein the processor is further adapted to store the anatomical context and processed image data sets to be searched and retrieved

via at least one of the Internet, a hospital information system, a radiological information system, and other information transmission infrastructure.

[c53] 53. The system of claim 45 wherein the processor is further adapted to automatically send detailed exam information to remote workstations or portable computing device via an information transmission infrastructure.

[c54] 54. The system of claim 53 wherein the processor is further adapted to automatically send detailed exam information which meets selected specified requirements determined in advance of transmission or determined adaptively by the processing system.

[c55] 55. The system of claim 45 wherein the processor is further adapted to tune at least one computer analysis algorithm based on information from model hierarchy computations stored in previous exams.

[c56] 56. The system of claim 45 wherein the processor is further adapted to generate statistical measurements based on the information from model hierarchy computations stored in previous exams.

[c57] 57. The system of claim 56 wherein the processor is further adapted to report results of the statistical measurements to a local or remote monitoring facility.

[c58] 58. The system of claim 57 wherein the processor is further adapted to report the results of the statistical measurements if predetermined criteria based on the system performance are met.